

Claims:

What is claimed is:

- 1 **1.** A method in a convolutional decoder for calculating branch labels
2 comprising the steps of:
3 selecting a group of four consecutive states, S_i , S_{i+1} , S_{i+2} , and S_{i+3} ,
4 wherein S_i and S_{i+1} have next states S_j and S_k in a first trellis
5 butterfly and S_{i+2} and S_{i+3} have next states S_{j+1} and S_{k+1} in a
6 second trellis butterfly;
7 loading state S_{i+3} into a convolutional encoder and setting the
8 convolutional encoder input bit to 1, wherein the convolutional
9 encoder parameters include a constraint length K and generator
10 polynomials $G_p[K-2:0]$, wherein p is an index from 0 to $p-1$ for
11 p -number of generator polynomials used to produce p -number of
12 encoder output bits $[V_{p-1}:V_0]$ and bit $G[0]$ represents a modulo-2
13 adder connection to the newest bit in an encoder shift register in
14 the convolutional encoder; and
15 computing a first branch label $BL[V_{p-1}:V_0]$ for the input equals 1
16 transition from state S_{i+1} to state S_k in the first trellis butterfly
17 using the formula
18 $V_p' = G_p[K-3] \text{ xor } V_p$
19 where $G_p[K-3]$ is the $K-3$ bit of the p^{th} generator polynomial and V_p
20 is the p^{th} bit of the state S_{i+3} encoder output bits $[V_{p-1}:V_0]$.

1 **2.** The method in a convolutional decoder according to claim 1 further
2 comprising the steps of:

3 determining that the convolutional encoder is configured as a recursive
4 convolutional encoder having a feedback polynomial $GF[K-2:0]$;

5 in response to determining that the convolutional encoder is configured
6 as a recursive convolutional encoder, computing the first branch
7 label $BL[V_{p-1}:V_0]$ for the input equals 1 transition from state S_{i+1} to
8 state S_k using the formula

9
$$V_p' = G_p[K-3] \text{ xor } GF[K-3] \text{ xor } V_p$$

10 where $G_p[K-3]$ is the $K-3$ bit of the p^{th} generator polynomial,
11 $GF[K-3]$ is the $K-3$ bit of the feedback polynomial, and V_p is
12 the p^{th} bit of the state S_{i+3} encoder output bits $[V_{p-1}:V_0]$.

1 **3.** The method in a convolutional decoder according to claim 1 further
2 comprising the steps of:

3 computing a branch label by setting a branch label for a transition from
4 state S_{i+3} to state S_{k+1} equal to encoder output bits $[V_{p-1}:V_0]$;

5 computing a branch label by setting a branch label for a transition from
6 state S_{i+2} to state S_{j+1} equal to the branch label for the transition
7 from state S_{i+3} to state S_{k+1} ; and

8 computing branch labels by setting branch labels for transitions from
9 state S_{i+2} to state S_{k+1} and from state S_{i+3} to state S_{j+1} equal to the
10 inverse of the branch label for the transition from state S_{i+3} to state
11 S_{k+1} .

- 1 **4.** The method in a convolutional decoder according to claim 1 further
2 comprising the steps of:
- 3 computing a branch label by setting a branch label for a transition from
4 state S_i to state S_j equal to $BL[V_{p-1}':V_0']$; and
- 5 computing branch labels by setting branch labels for transitions from
6 state S_i to state S_k and from state S_{i+1} to state S_j equal to the
7 inverse of $BL[V_{p-1}':V_0']$.
- 1 **5.** The method in a convolutional decoder according to claim 1 wherein
2 state indices j and k associated with states S_j and S_k , respectively, are
3 related by the formula
- 4
$$k = j + 2^{((K-2)-1)}.$$
- 1 **6.** The method in a convolutional decoder according to claim 1 further
2 including the steps of:
- 3 addressing a branch metric register file using two least significant bits
4 of a branch label for the input equals 1 transition from state S_{i+1} to
5 state S_k ; and
- 6 addressing the branch metric register file using two least significant
7 bits of a branch label for the input equals 1 transition from state
8 S_{i+3} to state S_{k+1} .

- 1 **7.** A branch metric unit for a Viterbi decoder comprising:
 - 2 a state counter for selecting a group of four consecutive states, S_i , S_{i+1} ,
3 S_{i+2} , and S_{i+3} , wherein S_i and S_{i+1} have next states S_j and S_k in a
4 first trellis butterfly and S_{i+2} and S_{i+3} have next states S_{j+1} and S_{k+1}
5 in a second trellis butterfly;
 - 6 a convolutional encoder loaded with state S_{i+3} and having a
7 convolutional encoder input bit equal to 1, wherein the
8 convolutional encoder parameters include a constraint length K
9 and generator polynomials $G_p[K-2:0]$, wherein p is an index from 0
10 to $p-1$ for p -number of generator polynomials used to produce
11 p -number of encoder output bits $[V_{p-1}:V_0]$ and bit $G[0]$ represents a
12 modulo-2 adder connection to the newest bit in an encoder shift
13 register in the convolutional encoder; and
 - 14 a branch label calculator for computing a first branch label $BL[V_{p-1}':V_0']$
15 for the input equals 1 transition from state S_{i+1} to state S_k in the
16 first trellis butterfly using the formula
17
$$V_p' = G_p[K-3] \text{ xor } V_p$$

18 where $G_p[K-3]$ is the $K-3$ bit of the p^{th} generator polynomial and V_p
19 is the p^{th} bit of the state S_{i+3} encoder output bits $[V_{p-1}:V_0]$.

- 1 **8.** The branch metric unit according to claim **7** further comprising:
2 a mode detector for determining that the convolutional encoder is
3 configured as a recursive convolutional encoder having a feedback
4 polynomial $GF[K-2:0]$;
5 a branch label calculator responsive to the mode detector for computing
6 the first branch label $BL[V_{p-1}':V_0']$ for the input equals 1 transition
7 from state S_{i+1} to state S_k , when the convolutional encoder is
8 configured as a recursive convolutional encoder, using the formula
9 $V_p' = G_p[K-3] \text{ xor } GF[K-3] \text{ xor } V_p$
10 where $G_p[K-3]$ is the $K-3$ bit of the p^{th} generator polynomial,
11 $GF[K-3]$ is the $K-3$ bit of the feedback polynomial, and V_p is
12 the p^{th} bit of the state S_{i+3} encoder output bits $[V_{p-1}:V_0]$.

1 **9.** The branch metric unit according to claim **7** wherein state indices j and
2 k associated with states S_j and S_k , respectively, are related by the
3 formula
4 $k = j + 2^{((K-2)-1)}$.

10. A data receiver for receiving convolutionally encoded data comprising:
- a receiver and demodulator for receiving user data;
 - a Viterbi decoder coupled to the receiver and demodulator, wherein the Viterbi decoder includes a branch metric calculator that includes:
 - a state counter for selecting a group of four consecutive states, S_i , S_{i+1} , S_{i+2} , and S_{i+3} , wherein S_i and S_{i+1} have next states S_j and S_k in a first trellis butterfly and S_{i+2} and S_{i+3} have next states S_{j+1} and S_{k+1} in a second trellis butterfly;
 - a convolutional encoder loaded with state S_{i+3} and having a convolutional encoder input bit equal to 1, wherein the convolutional encoder parameters include a constraint length K and generator polynomials $G_p[K-2:0]$, wherein p is an index from 0 to $p-1$ for p -number of generator polynomials used to produce p -number of encoder output bits $[V_{p-1}:V_0]$ and bit $G[0]$ represents a modulo-2 adder connection to the newest bit in an encoder shift register in the convolutional encoder; and
 - a branch label calculator for computing a first branch label $BL[V_{p-1}:V_0]$ for the input equals 1 transition from state S_{i+1} to state S_k in the first trellis butterfly using the formula

$$V_p' = G_p[K-3] \text{ xor } V_p$$
 where $G_p[K-3]$ is the $K-3$ bit of the p^{th} generator polynomial and V_p is the p^{th} bit of the state S_{i+3} encoder output bits $[V_{p-1}:V_0]$; and
 - a data output unit coupled to the Viterbi decoder for formatting and outputting the user data.

- 1 **11.** The data receiver according to claim **10** wherein the branch metric
2 calculator in the Viterbi decoder further includes:
- 3 a mode detector for determining that the convolutional encoder is
4 configured as a recursive convolutional encoder having a feedback
5 polynomial $GF[K-2:0]$;
- 6 a branch label calculator responsive to the mode detector for computing
7 the first branch label $BL[V_{p-1}:V_0]$ for the input equals 1 transition
8 from state S_{i+1} to state S_k , when the convolutional encoder is
9 configured as a recursive convolutional encoder, using the formula
10 $V_p' = G_p[K-3] \text{ xor } GF[K-3] \text{ xor } V_p$
- 11 where $G_p[K-3]$ is the $K-3$ bit of the p^{th} generator polynomial,
12 $GF[K-3]$ is the $K-3$ bit of the feedback polynomial, and V_p is
13 the p^{th} bit of the state S_{i+3} encoder output bits $[V_{p-1}:V_0]$.
- 1 **12.** The data receiver according to claim **10** further including an output
2 device coupled to the data output unit for outputting an audible signal.
- 1 **13.** The data receiver according to claim **10** wherein the data receiver is a
2 cellular telephone.